BIO-OPTICAL DYNAMICS AND THE FORECASTING OF BIO-OPTICAL VARIABILITY IN THE SEA

Allan R. Robinson, Principal Investigator
Jeffrey A. Dusenberry, Lead Scientist
Division of Engineering and Applied Sciences
Harvard University
29 Oxford St.
Cambridge, MA 02138-2901
phone: (617) 495-2819 FAX: (617) 495-5192 email: robinson@pacific.harvard.edu
Award #: N000149510033

LONG-TERM GOAL

Research on oceanic bio-optical processes and the prediction of ocean bio-optical properties requires coupled physical-biological-chemical models with the capability of real data initialization and assimilation. The goal is to develop and prove such models, focusing specifically on the bio-optical component. Ultimately, this research is directed towards the understanding of optical and biological processes in the sea, their variability and their response and sensitivities to local and remote forcings.

OBJECTIVES

The scientific/technical objectives of this project are i) to develop the bio-optical model component of the Harvard Ocean Prediction System (HOPS); ii) to apply the bio-optical model to the study of real ocean dynamical processes which govern the variability of bio-optical properties and associated effects on biogeochemical and ecosystem dynamical processes; iii) to initiate the development of a predictive capability for nowcasting and forecasting bio-optical variability in the coastal ocean and the deep sea, and iv) to develop data assimilation capabilities for satellite ocean color and other bio-optical data.

APPROACH

The approach is to construct interdisciplinary models in order to study the physical, biological (ecosystem), chemical and optical dynamics, their interactions and dependencies. Ecological, bio-optical and biogeochemical processes are highly non-linear and span a wide range of interactive spatial and temporal scales.

Both historical and real-time data sets are being used to guide the construction of idealized examples and carry out dynamical studies with realistic fields. The models are first calibrated using available data or subsets thereof. Such data may consist of long time-series mooring observations or repeated ship-based surveys. Subsequent sensitivity analyses are conducted to better understand sources of variability in biological and optical properties in the sea, and the responses of such properties to model parameter values and initial conditions. Dynamical studies,

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potentially using data assimilation of satellite ocean color data, are used to further our understanding of biological and optical responses to local and remote forcings. Predictive capabilities are being developed and tested by carrying out simulation experiments in real-time.

WORK COMPLETED

The first real-time test of the coupled bio-optical-physical models was carried out as part of the Phytoplankton Patchiness Studies by Ship and Satellite (P^2S^3) experiment in the eastern north Atlantic. As part of this endeavor, it was necessary to develop procedures for initializing the coupled models, using data as it became available. We now have the ability to operate in real time both on ship and on shore, with data and results being electronically transferred between ship and shore.

Calibration of the bio-optical models (using a prescribed upper ocean model) and preliminary sensitivity studies based on a subset of the Biowatt mooring time-series data have been completed. Calibration criteria for this experiment (primarily goodness of fit of model results to observed phytoplankton biomass) were identified and calibration protocols developed.

RESULTS

The first real-time tests of the bio-optical model components, performed during the P^2S^3 experiment, yield reasonable predictions of phytoplankton and nutrient distributions (Fig. 1). Results suggest that meteorological conditions can be the predominate determinants of variability in phytoplankton and nutrient distributions during storm or bloom conditions. At other times, mesoscale effects dominate such variability. Post-cruise calibration exercises are being used to further fine-tune model performance.

The Biowatt calibration exercises show that the coupled models can reproduce and maintain the position and magnitude of the deep chlorophyll maximum using a simple prescribed mixed layer model coupled with a 2-parameter photosynthesis-irradiance model (Fig. 2). Sensitivity studies suggest a strong dependence of the vertical position and magnitude of the deep chlorophyll maximum on vertical diffusion (via both chlorophyll and nutrient transport) and loss terms (phytoplankton respiration and grazing), as well as dependencies on bio-optical model parameters.

IMPACT/APPLICATIONS

Coupled optical-biological-physical models comprise an important investigative tool for studying both biological and physical processes in the world’s oceans. From a management perspective, such models are valuable not only as predictive tools, but as an aide for designing efficient sampling strategies.

TRANSITIONS

The bio-optical modules of HOPS are expected to make transitions with new releases of HOPS to the community. HOPS is currently being used at Naval Research Laboratories, the Naval

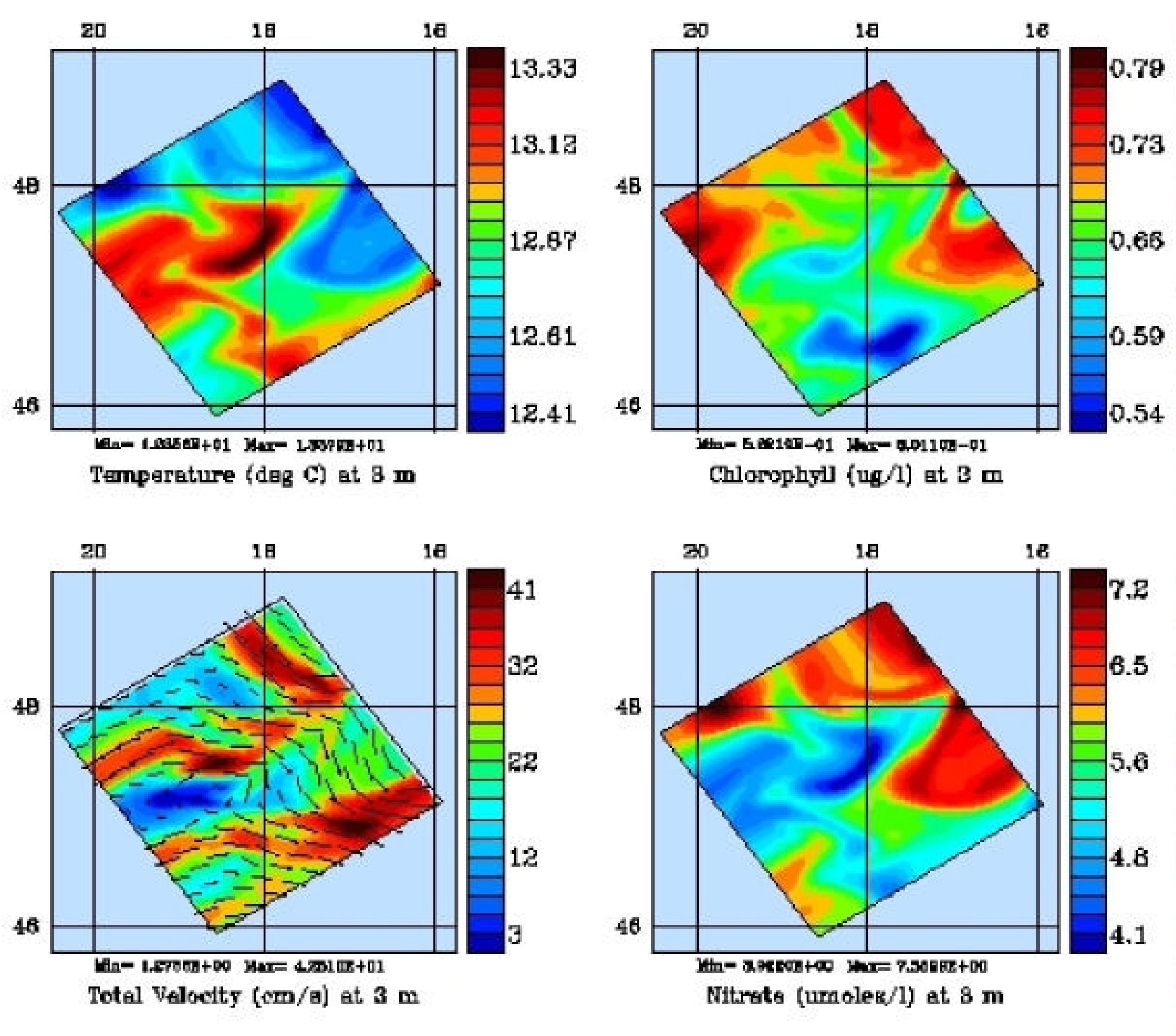

Figure 1 - *Simulated near-surface (3m) physical (temperature and velocity, left panel) and biological (chlorophyll and nitrate, right panel) fields. These fields represent a five-day forecast, done in real time using data collected on the R.R.S. Discovery for model initialization. The model was initialized for 21 April 1997, results are the forecast of 26 April 1997.*

Postgraduate School, the Jet Propulsion Laboratory (NASA), SACLANT Undersea Research Centre, and universities in the United States, Japan, Greece, Italy, Turkey and Israel.

RELATED PROJECTS

We are collaborating with Prof. T. Dickey at UCSB to work with the Biowatt and Coastal Mixing and Optics (ONR) projects. These analyses will be used to develop predictive capabilities in both the open ocean and coastal regions. We are also collaborating with Dr. M. Fasham (Southampton Oceanography Centre) as part of the P^2S^3 experiment. This cruise was used for the initial test of the bio-optical model component; subsequent analyses will be used to fine tune the model operation.

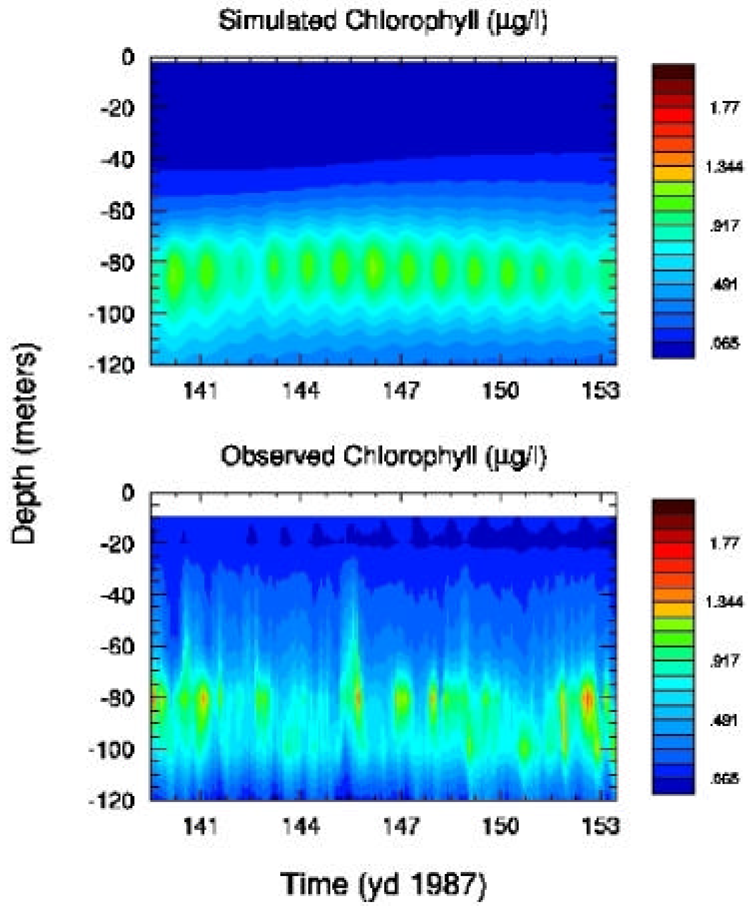

Figure 2 - *Simulated and observed chlorophyll distributions for the Biowatt mooring time-series. Simulation results are from a 1-D coupled bio-optical-physical model, using a prescribed mixed layer (20m) and a two-parameter photosynthesis-irradiance model*.

The bio-optical models will be used in two other projects as well: the Littoral Ocean Observing and Predictive System (LOOPS) project (ONR) and the Atlantic Fisheries Management and Information System (AFMIS) project (NASA).

REFERENCES

Dusenberry, J. A., C. J. Lozano, L. A. Anderson and A. R. Robinson. 1997. The Harvard Ocean Prediction System bio-optical model component. *In prep.*

Dusenberry, J. A., C. J. Lozano and A. R. Robinson. 1998. Interpretation and analysis of the Biowatt mooring data set using a coupled biological-optical-physical model. *In prep*.